METOC Human-System Information Interaction

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LONG-TERM GOALS

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14. ABSTRACT
The long-term goal of this effort is to improve the effectiveness of METOC information flow to the tactical users. This information flow includes both the data flow from the data sources to the METOC forecasters and the environmental impact information flow to the warfighters. As part of the 1 information flow, the project intends to understand how forecasters use complex visualizations to make a forecast, and to improve their workflow, visualization usage, and tools to increase the accuracy of their forecasts and decrease the time spent making a forecast. To achieve this goal, key components of a prototype system will be developed to test the hypotheses and refine theories of the information flow. Ultimately, the prototype of the information flow model will be transitioned to the METOC community for operational use and application in the warfare areas. This information interaction model can also be used by the research, development, acquisition, and training communities to identify where significant improvements can be made and to help identify metrics to evaluate the value of the improvements.

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OBJECTIVES

The scientific and technical objective of this project is to improve the workflow of METOC human-system interaction for generating useful MEOC products to warfighters. In this project a key objective is to develop an information interaction model. An information interaction system will also be prototyped based on the information interaction model to test whether a more efficient method for METOC personnel to present concise tactical weather information to the warfighters can be developed. We will focus our attention on the METOC information flow for the Air-Strike warfighters.

APPROACH

A team of cognitive scientists, METOC researchers, and system engineers takes the iterative observe-and-build-and-test approach to the problem. We apply this approach to a series of experiments where teams of forecasters, working in a simulated or actual carrier METOC offices (CV-METOC), make a pre-strike mission briefing package. We observe the forecast team in scenario-based laboratory simulations producing the weather forecast for the mock strike mission. We also observe ship forecasters in their operational environment performing their duties. We use cognitive research tools to analyze the observations during the experiment. We construct the information flow model from the analyses of the observations, and we test our hypotheses in the following experiments. We also develop visualization tools for assisting the information flow and generating tactical products.
The initial product will be an interactive information model which will depend on the understanding of not only the METOC forecasting and warfighter needs, but also the cognitive processes involved in forecasting and the role of visualizations in these cognitive processes. As a result of these analyses, we will construct two models. One is the workflow process model, which reflects the individual and group behavior in developing a strike forecast. The other is the information model, which reflects the utility of the end products for specific tactical applications. Finally, the interaction and feedback processes within the workflow and information models will be defined and evaluated. Once we have a model that can be described and tested, we can build a prototype that implements the model. This implementation will incorporate processes and interactions that are designed to improve the usefulness and acceptance of the forecast products.

WORK COMPLETED

This research project is a collaborative effort among several research groups that are specialists in cognitive research, meteorological and oceanographic information systems, and strike mission planning research. During this past year, we have analyzed the observations collected during two experiments conducted in July 2000. The analyzed result was used as the basis of our hypotheses for the 2001 Experiment, which was conducted in Feb 2001.

2001 Experiment: The 2001 Experiment was conducted on the USS CARL VINSON (CVN-70) in the OA Division office (Weather Office) during the period Feb 11- 16, 2001. CARL VINSON was participating in one of the pre-deployment Battlegroup workup exercises referred to as Composite Training Unit Exercise (COMPTUEX). Observations of the experiment were collected during the first week of the exercise as the ship operated in SOCAL OPAREA (coastal waters adjacent to Southern California).

The purpose of the experiment is to test the following hypotheses:

- Naval tactical operators could use meteorology and oceanography (METOC) information that is more accurate, more timely, and with higher resolution than is being routinely provided.
- Automation of the repetitive steps in the forecast process could help standardize procedures and free time for more important cognitive tasks.
- Information-rich intuitive visualizations could help forecasters extract more knowledge from the weather data they have at hand.
- The technicians who support the forecasters may not always be familiar with how to retrieve the necessary parameter information needed as inputs for tactical decision aids.

From the observations, we evaluated workflow and visualizations used by METOC personnel to construct weather impact information in support of naval operations in general, and naval air strike in particular. The observing team collected forecasting workflow information including videotapes of weather office procedures, timings of each task, notes of forecaster's activities, notes of weather office personnel interviews, notes of pilot interviews, and notes of staff interviews.
Specific data taken from the OA Division to assist the analysis included the products which a carrier weather office produces during tactical operations, the data required to create these weather products, the average time it takes to create these products, and smaples of mesoscale atmospheric model output (i.e., for studying small scale weather features).

The operating schedule of the OA Division was based on the 12-hour watch. Each watch consisted of a forecaster (e.g., an Aerographer with an E6 grade and specialized forecasting training) and three technicians (Aerographers with limited METOC training). Daily activities of the experiment can be found at http://pluto.apl.washington.edu/metoc_hcs . The forecaster had the sole responsibility to produce the standard set of the products. Technicians were on call to perform the required duties ranging from downloading data/images to executing tactical decision aids. The logistics of the daytime observations were very difficult. The observation was often interrupted by the OA Division daily duties including training and hosting visitors. The physical space in the the OA Division is very limited, in many occasions, project observers had to leave the room to allow the OA Division to conduct its normal business. However, during the night shift, observers had no interruptions to record the forecasting procedures (see Figure below).

	Elapsed Time	Session	
1st Session	0:16:10	0:15:50	98%
2nd Session	0:00:43	0:00:43	100%
3rd Session New	0:05:20	0:04:20	81%
4th Session New	0:13:13	0:12:13	92%
5th Session New	1:30:00	1:09:57	78%
6th Session New	0:18:00	0:17:30	97%
Net	2:23:26	2:00:33	84%

Figure: A typical time analysis summary of forecaster's time used in the night shift forecasting. Overall, forecasters were able to concentrate on the task at hand about 84% of time.

Parallel Experiment: The NUWC team member had an excellent opportunity to conduct an extended replication of the METOC experiment at Royal Australian Navy (RAN). This parallel experiment provided us an opportunity to observe a totally independent group performing the identical function. The data collected could validate our Qualitative Mental Model (QMM) theory on how METOC forecasters formulate their thought processes and make their forecasts. Both differences and similarities would assist us in understanding the workflow process. Expert Interviews: In addition to the 2001 Experiment, the team made visits to METOC activities to obtain their approaches toward the METOC data workflow. These METOC activities included Naval Postgraduate School, Fleet Numerical METOC Center, NPMOC San Diego and NPMOF Whidbey Island.

RESULTS

Validation of the workflow process through the concept of the Qualitative Mental Model (QMM) is most significant. Through the independent data collected from RAN, the concept of the QMM refined in 2000 is still valid.

The ship communication link is limited. A regional METOC center can assist the ship forecasters to gather information by staging "critical" data at one central location. From the data collected in the 2001 experiment, the team has a list of products that the METOC regional sites should be gathering. Currently, the team members are working with Naval Postgraduate School to refine this "critical" data list. In addition, the tactical weather impact information should also be staged by the regional center. As we observed that the METOC data/information have gone to the warfighters directly in some circumstances, it is our conclusion that these tactical impact products can be automatically ingested into the tactical impact spreadsheet used by the Battlegroup.

Currently, the forecasters are taking a default approach in gathering the information (use whatever is available), instead of the funneling approach in which one would systematically seek out appropriate information. In many occasions, the team observed that the forecasters use the mesoscale model outputs without clear understanding of their strengths and weaknesses as compared to use of a global model (i.e., the mesoscale and global model output are used interchangeably). A forecast checklist would be very helpful for inexperienced forecasters to take a systematic approach to forecasting.

Much forecast information produced by the forecasters is repeated in many different forecast products. The forecast office can use an information storage center and message generation application for transferring the information from one format to the other. The benefit of this information management is to force consistency in the product content.

IMPACT/APPLICATIONS

This important collaboration brings together researchers from many disciplines to study the critical problem of information flow from METOC to Strike planners by focusing on the nature of workflow. In the 2001 Experiment, research has progressed through carefully designed steps. We have advanced our theory on the METOC workflow, and we have fitted our observation methodology for use on board an aircraft carrier. The objectives of the 2001 Experiment on board the USS CARL VINSON were to validate workflow concept through the QMM and to test if forecasters can get tactical weather information from the mesoscale weather prediction model output. We believe that the workflow model will be the key for building the future METOC information infrastructure. From the 2001 experiment results, we suggest that 1) data/information staging for the forecasters is a key area for improvement of the workflow, 2) the data staging can assist forecasters to expedite the "Verify and Adjust" steps in the QMM, 3) the automatic linkage of tactical impact variables can save forecasters valuable time in producing a product, and 4) the in-field observations reveal more than the laboratory experiment. The scenario based laboratory experiment is an excellent methodology for discovering workflow problems, but actual observation of the ship operations cannot be neglected.

Some of these results will be presented to the Naval METOC Personnel Training Center in Gulfport, Mississippi and can impact their mid-career level training for METOC personnel. We believe that our analyses show the information interaction that leads to improved forecasting in support of strike operations. Our analyses can also be used for identifying common errors and areas where improved training would be helpful.

TRANSITION

The findings of this study will form the basis for METOC data workflow design. The recommendations are transitioned to the 6.3 Environmental Visualization project. The approaches of the FNC Environmental Visualization (EVIS) project (starting in FY-02) are based on the project findings as summarized in the Results Summary.

The findings of this study will also be transitioned to the Naval METOC Personnel Training Center for developing their training curriculum.

The workflow observation technology can be transitioned to the METOC community for discovery of workflow problems in other disciplinary areas.

RELATED PROJECTS

Environmental Visualization. FNC/KSA ONR $1.2M, FY-2002 (Ballas)

Nowcasting for Next Generation of Navy, ONR $400K/yr, 1999-2004 (Cook)

Human Centered Scientific Visualization. ONR/NRL, 2000-2002, (Trafton)

Integration and Visualization of Multi-Source Information for Mesoscale Meteorology: statistical and Cognitive Approaches to Visualizing Uncertainty. ONR MURI, $5M, 10/2001 – 4/2006 (Raftery)

SUMMARY

METOC forecasters not only extract information from visualizations, they create a qualitative mental model (QMM) and reason with it. They then use their QMM to generate quantitative information. We have refined this model this year to explore how experts and novices differ in their use of their QMM and the forecasting process in general, as well as replicating the basic finding.

Through the 2001 experiment, we found that a data staging strategy can be used to assist the ship forecasters gathering information. The data and information can be prepared and staged to improve the workflow around the ship forecasters. Concrete steps have been adopted in the work plan for the new ONR Future Naval Capabilities (FNC) project.

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